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The crown effect of Persian Oak (*Quercus brantii* LindI.) high trees on the physical and chemical properties of soil in Iran Zagros forests (Case study: Dalab canyon, Ilam County)

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Key words: canopy cover, Persian Oak, physical properties, chemical properties, Zagros forests.

Abstract

Forest trees, especially ones growing in the arid and semi arid regions, have a significant impact on the soil under and outside the tree crown and function of these ecosystems. Given that the study of relation between the trees and soil is one of the key factors in the forest management and planning, this study was conducted to investigate the crown effect of Persian Oak (*Quercus brantii*) high trees on some soil physical and chemical properties (Organic matter (OM), Electrical conductivity (EC), Bulk density (BD), pH, Nitrogen (N), Phosphorous (P), Potassium (K)) in the Dalab canyon forests of Ilam, Iran. By random transect method of sampling, 10 trees were select and soil samples were taken from two 0-15cm and 15-30cm depths, under and outside the crown of tree. Results show that *Q.brantii* significantly reduces the soil pH and BD in tow depths, increases the P, N (0-15cm) and K (15-30cm) in the beneath of tree crown in compared to outside of it. Increase of OM in tow depths and from beneath and outside of tree crown revealed a non significant difference. Generally it can be said that *Q.brantii* has been shown to improve physical and chemical properties of soil.

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Introduction

The underlying assets of any country are natural resources that in order to protect and restore of them we need a scientific, efficient and proper management paradigm. This requires having accurate information about vegetative quantitative and qualitative properties, understanding the relationships between species and environmental factors and soil properties such as physical and chemical properties that can show a correct understanding of relationships between plants and soil. Zagros forests with approximately 5 million hectares extent (Mohaje, 2005), as an important part of Iranian forests, have been molested since ancient times. These aggressions in various forms have provided setting of forest destruction. This caused the loss of organic carbon, soil structure degradation, soil hydraulic conductivity and increasing of soil BD (Canadell and Noble, 2001). In other words, forest degradation besides direct impact on the soil by change or destruction of vegetation cover; indirectly will affect the physical and chemical properties of soil and these relations are fully interrelate (Wang, 2007). Accumulation of plants residual is a major driver of significant changes in soil physical and chemical properties, especially in arid and semi arid environments (Charley and West, 1976). Various founding indicate that forest trees has a important role in increasing of soil fertility (Dahlgren *et al*, 1994; Camping *et al*, 2002; Dahlgren *et al*, 2003). Evidence indicate that trees in forest ecosystems through the creating biogeochemical processes provide fertile soils in the beneath of their crown (Camping *et al*, 2002). Peterson *et al* (2002) found that soil beneath the *Q. macrocarpa* crown has a more carbon than outside one. Results of Jackson *et al* (1990) indicate that in the Mediterranean regions of California, soils beneath the red Oak crown in comparing to open grassland have more and longer return period of Balamurgan *et al* (2000) explained the effect of different plants in increasing of soil nutrients by behavior of nutrients, soil type and nature, OM accumulation, microbial activities and degrees of mineral resistance against weathering. With regard to rising trend of deforestation, reports show that in several cases trees have positive effects on the soil physical and chemical properties.

Previous studies have explored how tree species affect soil properties in forests, and those that have report variable results. Some studies found significant species effects on belowground C and N cycling in rain forests (Reed *et al*, 2008; Wieder *et al*, 2008; Van Haren *et al*, 2010), while Powers *et al*, (2004) found no significant species effects in an eastern Costa Rican rain forest. However, the majority of research to date has focused on relatively species-poor Mediterranean forests.

The aim of this study was to investigate crown effect of *Q.brantii* trees on the soil physical and chemical properties and the need to conserve and restore of these forests with offering scientific and efficient management plans in Dalab canyon forests of Ilam County.

Materials and methods

Study area

Ilam province with 2002794.6 hectare extent, constitute approximately 1.2 percent of Iran area. Contribution of Ilam forests among whole Iranian forest is 641667 hectare that dominated by Persian Oak (*Q.brantii*) species. This study conducted in a part of Zagros forests that located in 8 Km off East of Ilam county, namely Dalab canyon. Extent of study area is located between 46°22'15" to 46°25' 27" E longitudes and 33° 41' 01" to 33° 43' 13" N latitudes. According to Amberge method, the climate of study area is cold and semiarid. The mean annual temperature and mean annual precipitation are 9.16 °C and 525 mm, respectively. Soil survey of the study area shows that soil is predominantly shallow to moderately deep with medium texture and located on the calcareous bedrock.

Data collection

Using random transect method of sampling, 10 trees were selected and 30 combined soil (CS) samples were taken from two 0-15cm and 15-30cm depths, beneath and outside the crown of trees. CS samples were dried in outdoor air for 24 hours and passed through a sieve of 2 mm after slamming. Then in the lab defined properties were measured. Soil texture was determined by hydrometer method, EC was measured by electronic EC meter in saturated soil state, pH was determined by electronic pH meter in saturated soil state, BD was determined by cylinder method, soil OM measured by Walky black method, available K was measured by flame Photometer and using ammonium acetate and available P was determined by Olson method and Spectrophotometer device.

Statistical methods

Kolmogorov-Smirnov test was used to assess data normality. Homogeneity of variance tested with Leven test and one way Analysis of variance (ANOVA) implemented for overall comparison of stands and for mean comparing analysis, Duncan test was used.

Results

Table 1 represents the quantitative values and the standard deviation of variables that separated by total samples, beneath of crown samples and outside of crown samples in tow depth (0-15cm and 15-30cm).

Table 1. Quantitative values ± standard deviation of soil variables.

	Under the tree crown		**Outside the tree crown**	
Depth (cm)	**0-15**	**15-30**	**0-15**	**15-30**
pH	7.20±0.19	7.56±0.21	6.81±0.05	7.31±0.06
EC	0.79±0.09	0.53±0.13	0.99±0.31	0.50±0.07
BD	0.79±0.05	0.99±0.03	0.92±0.07	1.1±0.11
OC	3.73±0.14	2.59±0.37	3.44±0.28	2.56±0.61
OM	6.42±0.22	4.60±0.54	5.98±0.54	4.42±0.42
K	532±118	361±80.1	528±85.6	220±31.6
P	165±26.8	87.2±10.3	114.4±13.8	79.5±14.8
N	0.28±0.006	0.21±0.023	0.26±0.018	0.20±0.018

pH: measure of acidity; EC: Electrical Conductivity; BD: Bulk Density; OC: Organic Carbon; OM: Organic Matter; K: Potassium; P: Phosphorus; N: Nitrogen

Table 2 shows the ANOVA results of soil variables. Based on the significant values there is a significant differences ($p < 0.05$, 95% confidence level) between studied variables. Figs 1 and 2 shows the mean comparisons of pH, EC, BD and OM soil variables at the depths of 0-15cm and 15-30cm under and outside the tree crown based on Tukey test. Between pH and BD variables, there is significant difference at the two depths under and outside the tree crown. Under tree crown content of OM in two depths is more than outside the tree crown but no significant differences were observed. Between under and outside the tree crown significant differences were observed for EC at the depth of 0-15cm. Figs 3 and 4 represents the Duncan test for mean comparisons of macronutrient elements. Significant differences were observed for N and P (at the 0-15cm depth) between under and outside the tree crown but no significant difference were observed for these elements at the 15-30cm depth. The quantities of K in the under and outside of tree crown at the 15-30cm depth shows a significant difference and at the 0-15cm of soil depth no significant difference were observed. Total value of macronutrient elements (both under and outside of tree crown) is more at the 0-15cm depth in comparison to the depth of 15-30cm.

Table 2. One Way Analysis of Variance (ANOVA) for soil variables.

Variable	Source	SS	df	MS	F	Sig
pH	Between	2.645	7	0.378	14.642	0.000**
	Within	1.342	52	0.26		
	Total	3.987	59			
EC	Between	2.787	7	0.398	25.858	0.000**
	Within	0.801	52	0.015		
	Total	3.587	59			
OM	Between	38.938	7	5.563	35.712	0.000**
	Within	8.100	52	0.165		
	Total	47.038	59			
OC	Between	13.573	7	1.939	32.480	0.000**
	Within	3.104	52	0.060		
	Total	16.377	59			
BD	Between	0.460	7	0.066	18.409	0.000**
	Within	0.186	52	0.004		
	Total	0.646	59			
K	Between	1100558.33	7	157222	22.124	0.000**
	Within	369540.000	52	7106		
	Total	1470098.333	59			
P	Between	42916.133	7	6130	20.861	0.000**
	Within	15282.105	52	293		
	Total	508198.147	59			
N	Between	0.070	7	0.10	23.296	0.000**
	Within	0.022	52	0.000		
	Total	0.092	59			

***: Statisticaly Significant ($p < 0.05$), 95% confidence level*

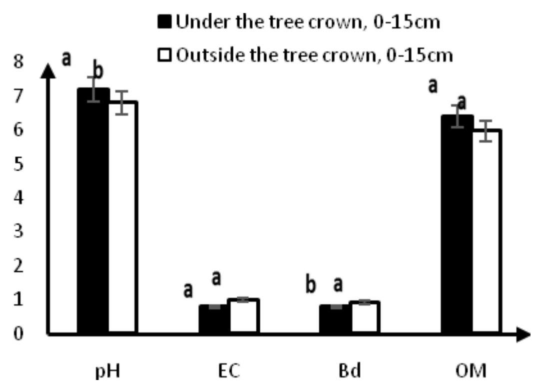

Fig. 1. Mean comparisons of pH, EC, BD and OM in 0-15cm depth of soil samples under and outside the tree crown

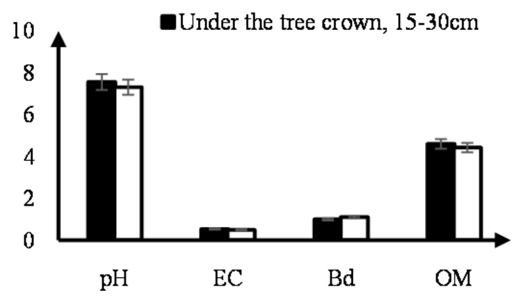

Fig. 2. Mean comparisons of pH, EC, BD and OM in 15-30cm depth of soil samples under and outside the tree crown.

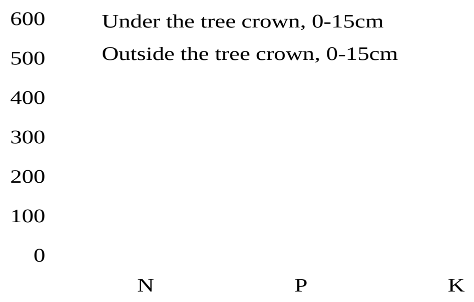

Fig. 3. Mean comparisons of N, P and K in 0-15cm depth of soil samples under and outside the tree crown.

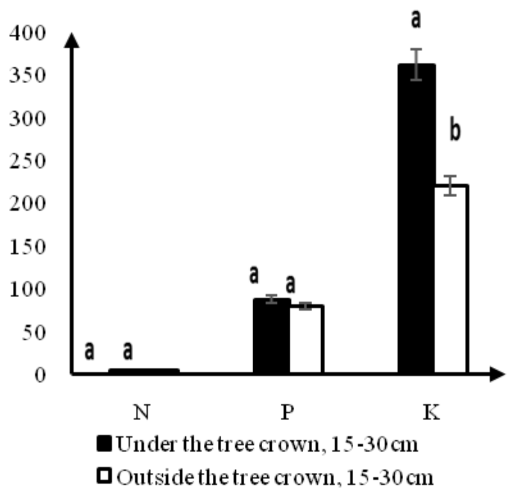

Fig. 4. Mean comparisons of N, P and K in 15-30cm depth of soil samples under and outside the tree crown.

Discussion

Based on results obtained in this study, OM content under the tree crown was higher than one in the outside of tree crown although this difference was not statistically meaningful between the two depths and under and outside the crown of trees. The presence of dense herbaceous species outside the tree crown and sloping of the area are reasons for high level of OM outside the tree crown. Sebastia *et al* (2008) by examining the amount of organic matter in the Togo grasslands of West Africa found that forest OM is more than pasture lands. Gallardo (2003) showed that individual Oak trees are a main driver for higher accumulation of OM, organic carbon and N in the under crown space than in areas outside the tree crown. Also this study indicates that crown of Oak trees has been increased the EC values of under crown soil in comparison to outside soil of tree crown. This increase of EC values under the tree crown statistically was significant at the 0-15cm depth. With increasing the soil depth, EC values showed a decreasing trend in the both under and outside the tree crown areas. Reducing the soil surface temperature and shading due to presence of trees, result in less evaporation of water and mineral transmission from deep soil to the surface, while organic acids resulting from the decomposition of OM helps more dissolving of minerals and release of ions. Zhang *et al* (2008) examined the salsola pasture plants and found that the EC values under crown of plants were increased. With a comparative analysis between tow depths (0-10cm and 10-20cm), they found that EC values with increasing of soil depth dramatically are reduced. Balamurgan *et al* (2000) did not observe a significant reducing of EC between under and outside of tree crown of Eucalyptus species. The results of this research did show significant differences on the BD under and outside the tree crown at the tow depths because of decline in the organic carbon and compactness of soil by taking distance from tree. Also, soil density was greater in the outside the tree crown than under the tree crown.

Soil pH is one of the most important properties of site productivity (Jobbagy and Jackson, 2003). In this study, soil pH significantly was different from tow depths both under and outside the tree crown. All Soil samples were neutral to slightly alkaline due to limestone bedrock of study area. Total N under the tree crown was greater than outside the tree crown. This increase in the N was significantly different at the 0-15cm depth of soil. Expressed by Zhang *et al* (2008), total N under the tree crown of salsola is 4 to 5 times more than outside the tree crown. Barth and Klemmedson (1978) stated that one of the drivers of

N accumulation under the tree crown of Prosopis species probably is the lack of favorable conditions for denitrification process and sublimation of ammonium under the tree crown than outside the tree crown area. Shukla *et al* (2006) reported that the total N concentrations of soil under the tree crown were greater than outside the tree crown and the total amount of N decreases with increasing of soil depth in the beneath of tree crown. The level of P macronutrient element, influenced by tree crown, shows a significant difference at the 0-15cm depth in compared to outside the tree crown, if that this increase at the 15-30cm depth of soil was not so significant under and outside the tree crown. The amount of this element under and outside the tree crown decreased with increasing of soil depth. Wetzel *et al* (2000) studied soil of under and outside the tree crown of 57 pasture species and observed that the soil available P under the tree crown significantly is greater than open space from plant crown and it has dramatically declining trend with increasing of soil depth. As stated by them, the reason for this trend is increase the OM in shade area and initial depth of soil because OM is one of the important drivers in nutrient storing especially in the poor soils influenced by tree cower, shows a significant increasing level under the tree crown than outside the tree crown at the 15-30cm depth of soil while depth of 0-15cm did not show a significant difference. The value of this element as well as other parameters decreased with increasing depth of soil. Mishra *et al* (2003) found no significant differences between K levels under and outside the trees crown of Eucalyptus species and this are associated with the release of K from K-bearing minerals or release from decomposing litter under the tree crown. Wang *et al* (2000) stated that increased secretion of organic acids by plant roots leading to greater liberalization of available K by plants. According to the mentioned effects it is clear that presence of trees in general have a positive influence on soil properties and therefore the disappearance of them as results of various drivers leading to the decline in soil quality and susceptible soil to the erosion and these entries makes clear the necessity of further preservation and restoration of these forests.

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